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Alleva et al.

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[54] **TEXT NORMALIZATION USING A CONTEXT-FREE GRAMMAR**

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[22] Filed: **Apr. 3, 1997**

[51] **Int. Cl.**^{6} **G10L 7/08**

[52] **U.S. Cl.** **704/235**; 704/257

[58] **Field of Search** 704/235, 273, 704/243, 231, 9, 251, 260, 200, 255, 257, 270, 272

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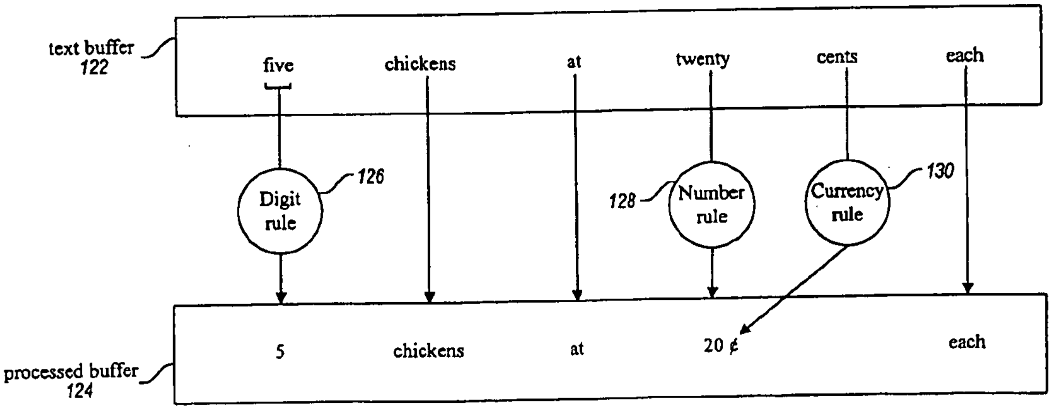
Primary Examiner—Richemond Dorvil

Attorney, Agent, or Firm—Westman, Champlin & Kelly, P.A.

[57] **ABSTRACT**

A text normalizer normalizes text that is output from a speech recognizer. The normalization of the text produces text that is less awkward and more familiar to recipients of the text. The text may be normalized to include audio content, video content, or combinations of audio and video contents. The text may also be normalized to produce a hypertext document. The text normalization is performed using a context-free grammar. The context-free grammar includes rules that specify how text is to be normalized. The context-free grammar may be organized as a tree that is used to parse text and facilitate normalization. The context-free grammar is extensible and may be readily changed.

50 Claims, 16 Drawing Sheets



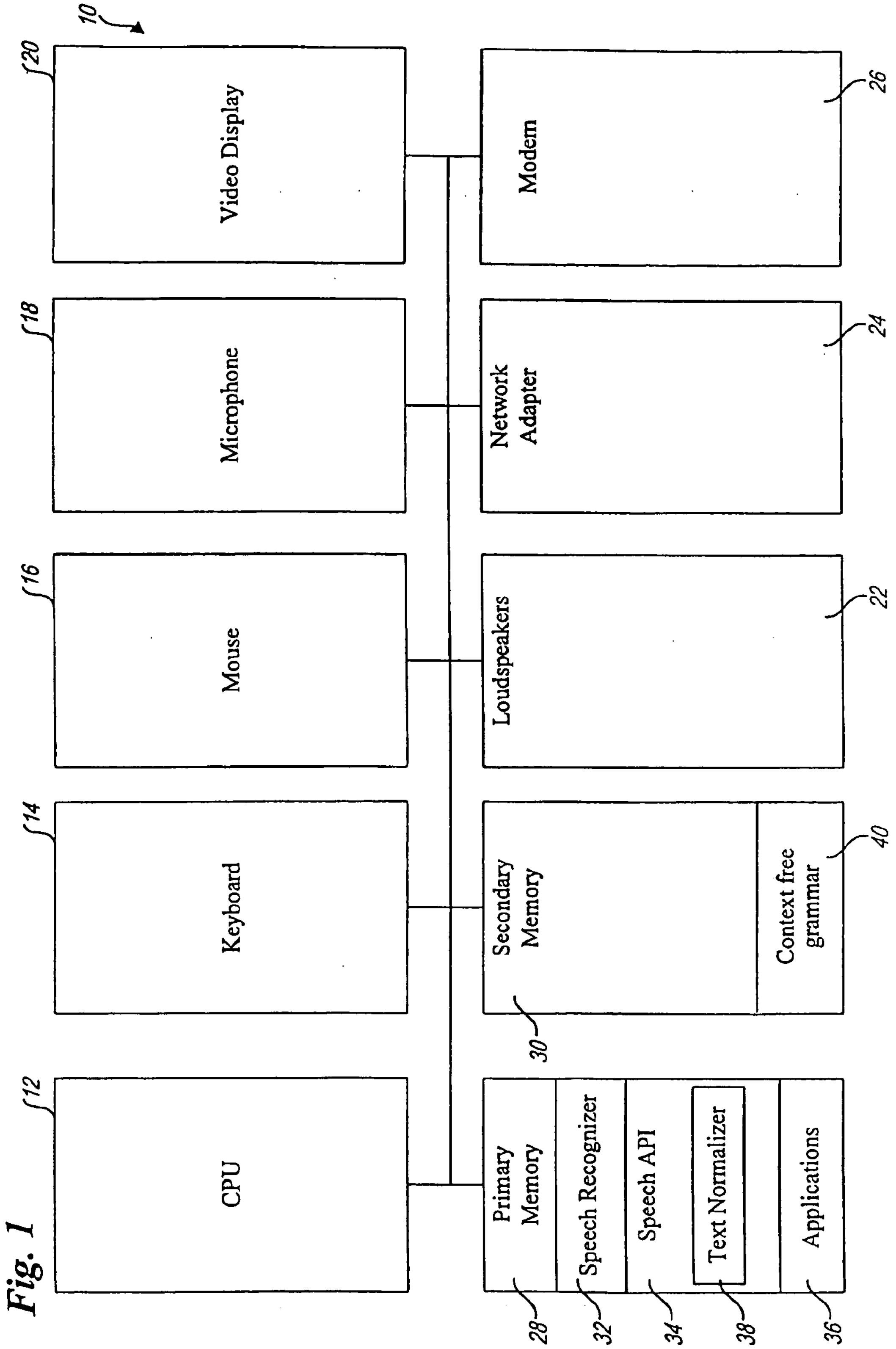

10
20
Video Display
Modem
26
18
Microphone
Network Adapter
24
16
Mouse
Loudspeakers
22
14
Keyboard
Secondary Memory
30
Context free grammar
40
12
CPU
Primary Memory
28
Speech Recognizer
32
Speech API
34
Text Normalizer
38
Applications
36

Fig. 1

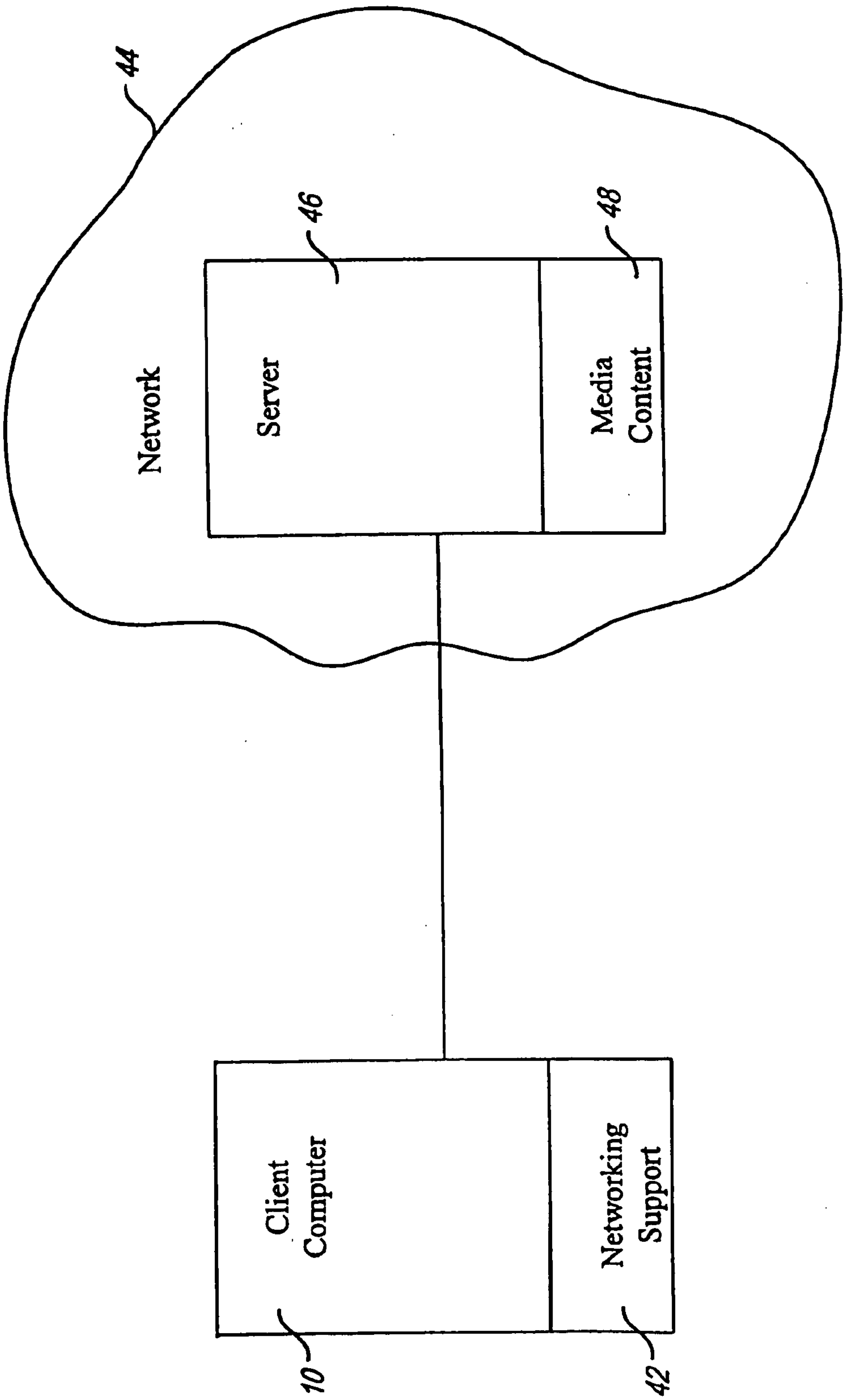

44
46
48
Network
Server
Media Content
Client Computer
Networking Support
10
42

Fig. 2

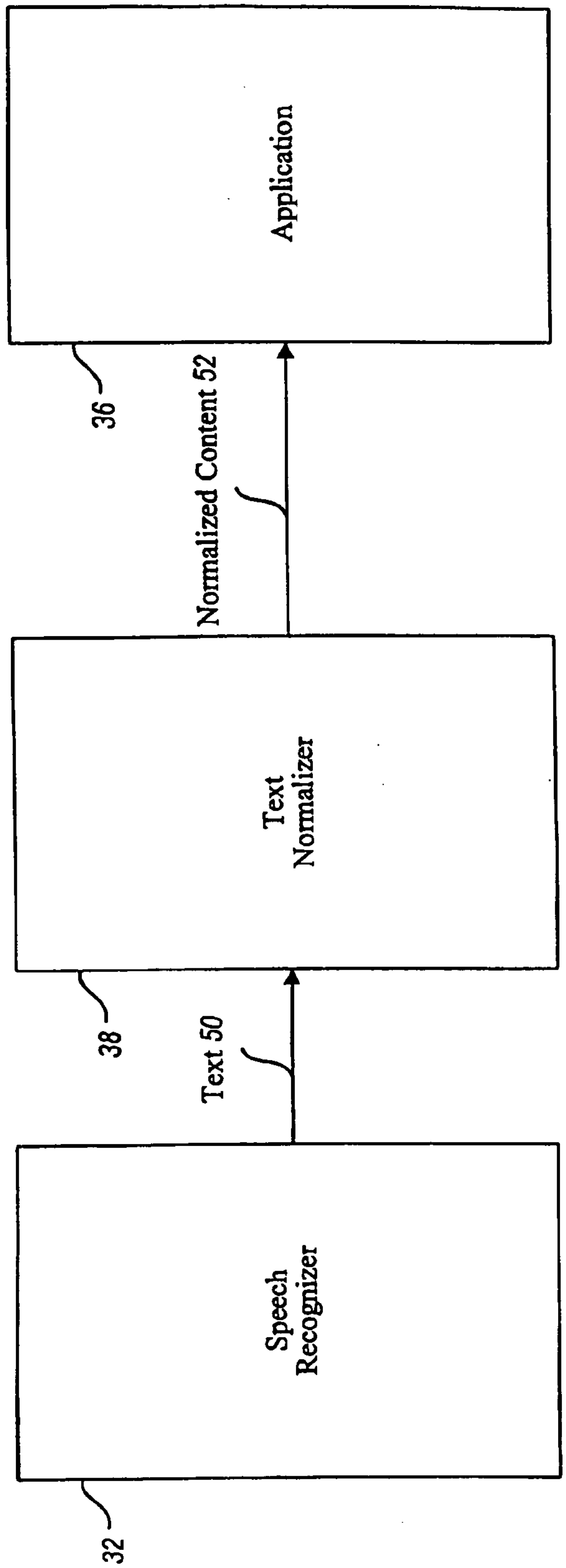

Application
36
Normalized Content 52
Text Normalizer
38
Text 50
Speech Recognizer
32

Fig. 3A

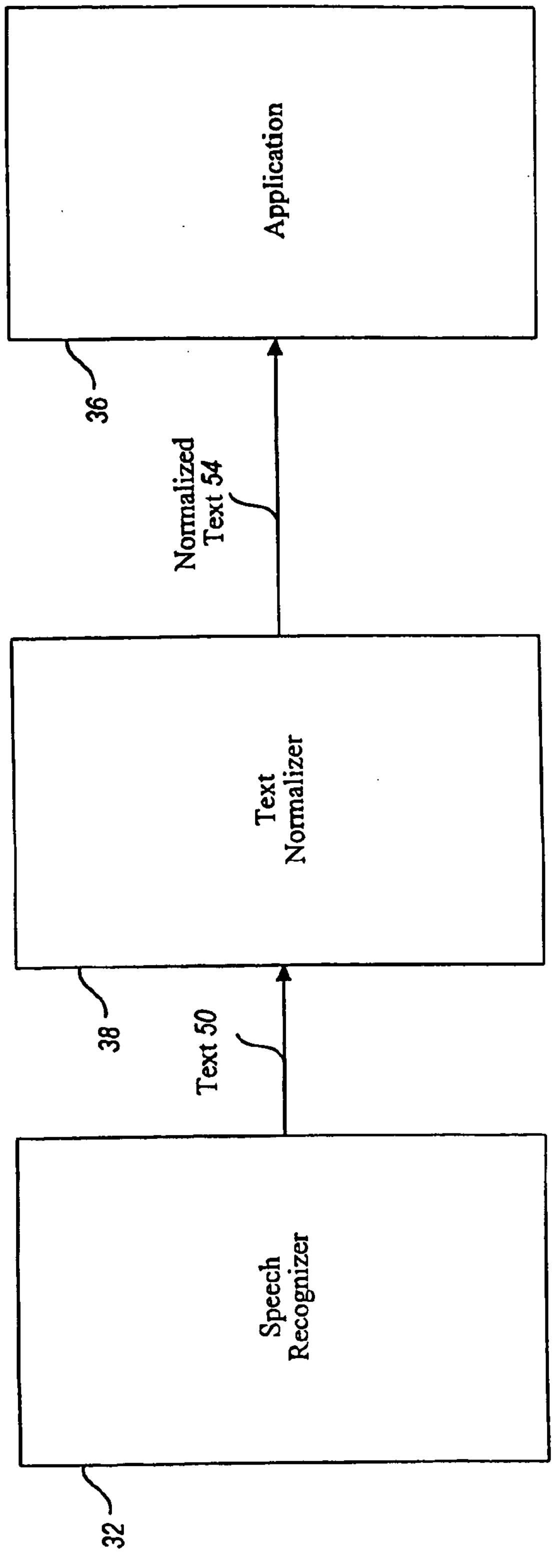

Speech Recognizer
32
Text 50
38
Text Normalizer
Normalized Text 54
36
Application

Fig. 3B

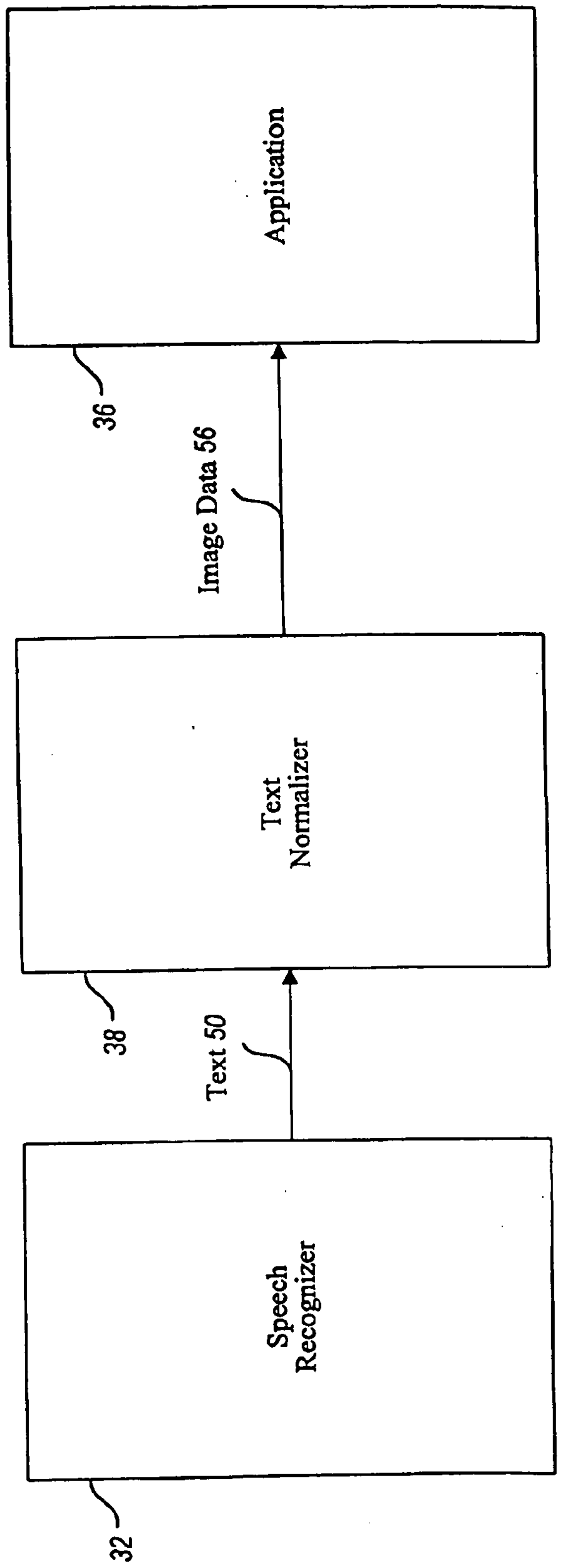

Application
36
Image Data 56
Text Normalizer
38
Text 50
Speech Recognizer
32

Fig. 3C

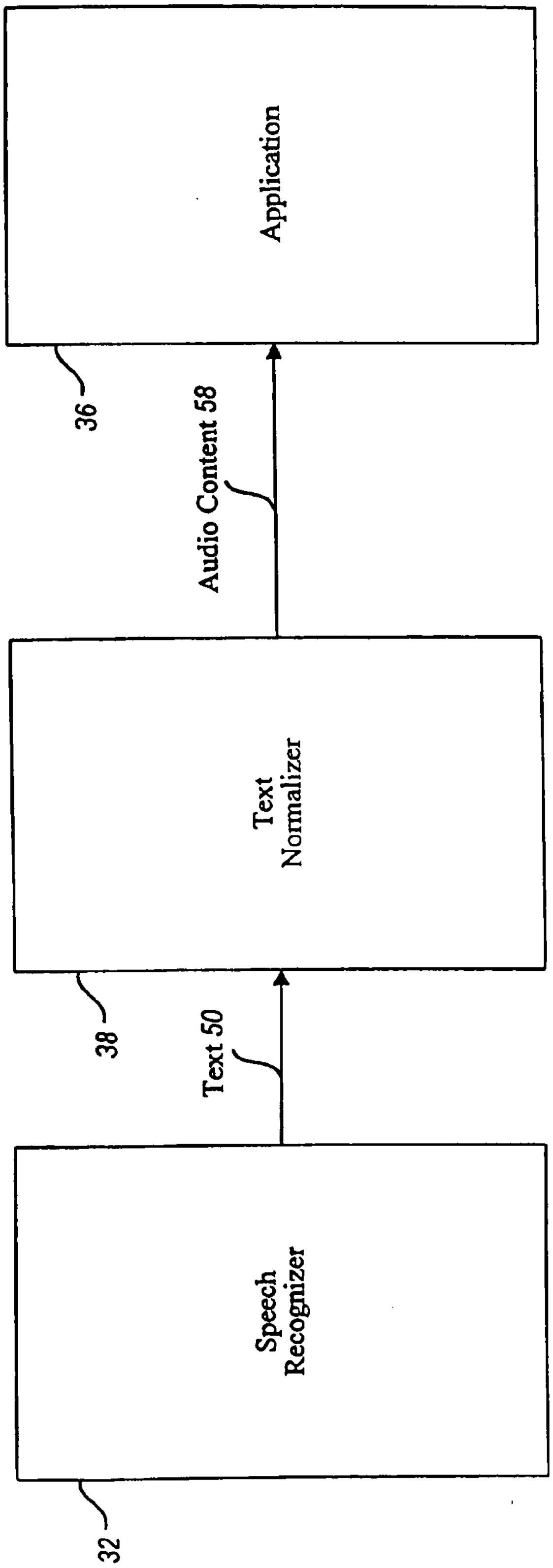

Application
36
Audio Content 58
Text Normalizer
38
Text 50
Speech Recognizer
32

Fig. 3D

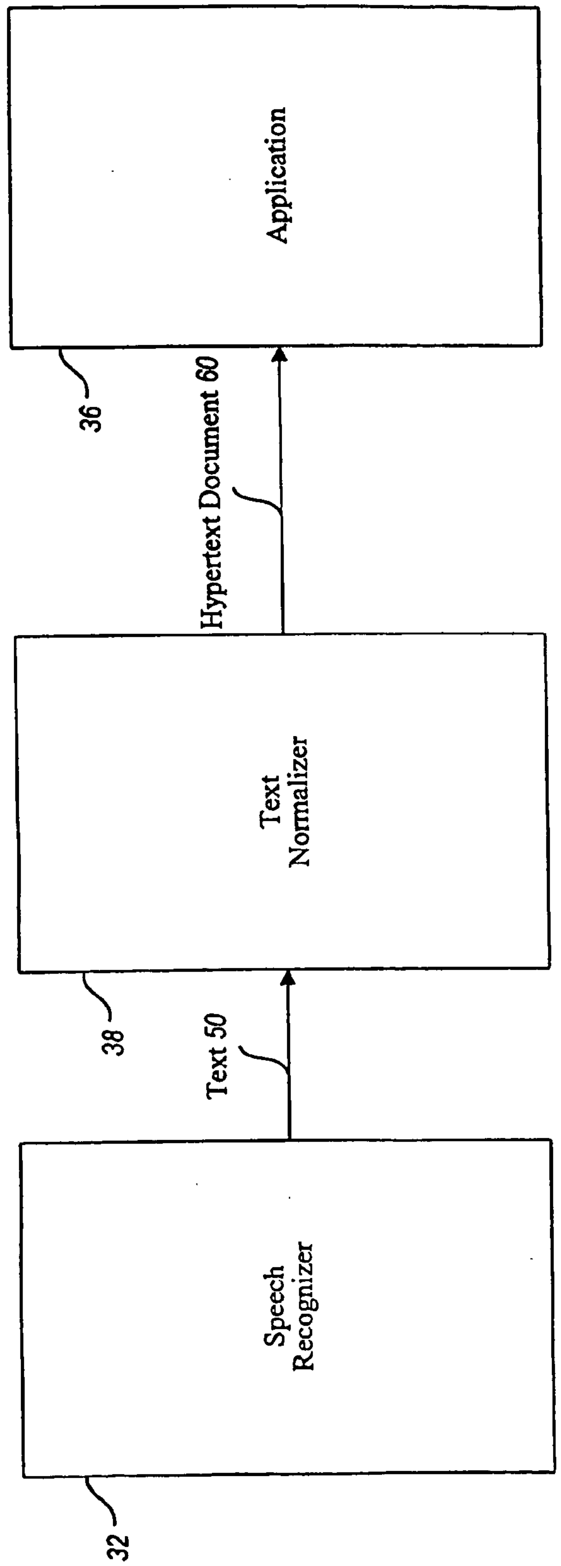

Application
36
Hypertext Document 60
Text Normalizer
38
Text 50
Speech Recognizer
32

Fig. 3E

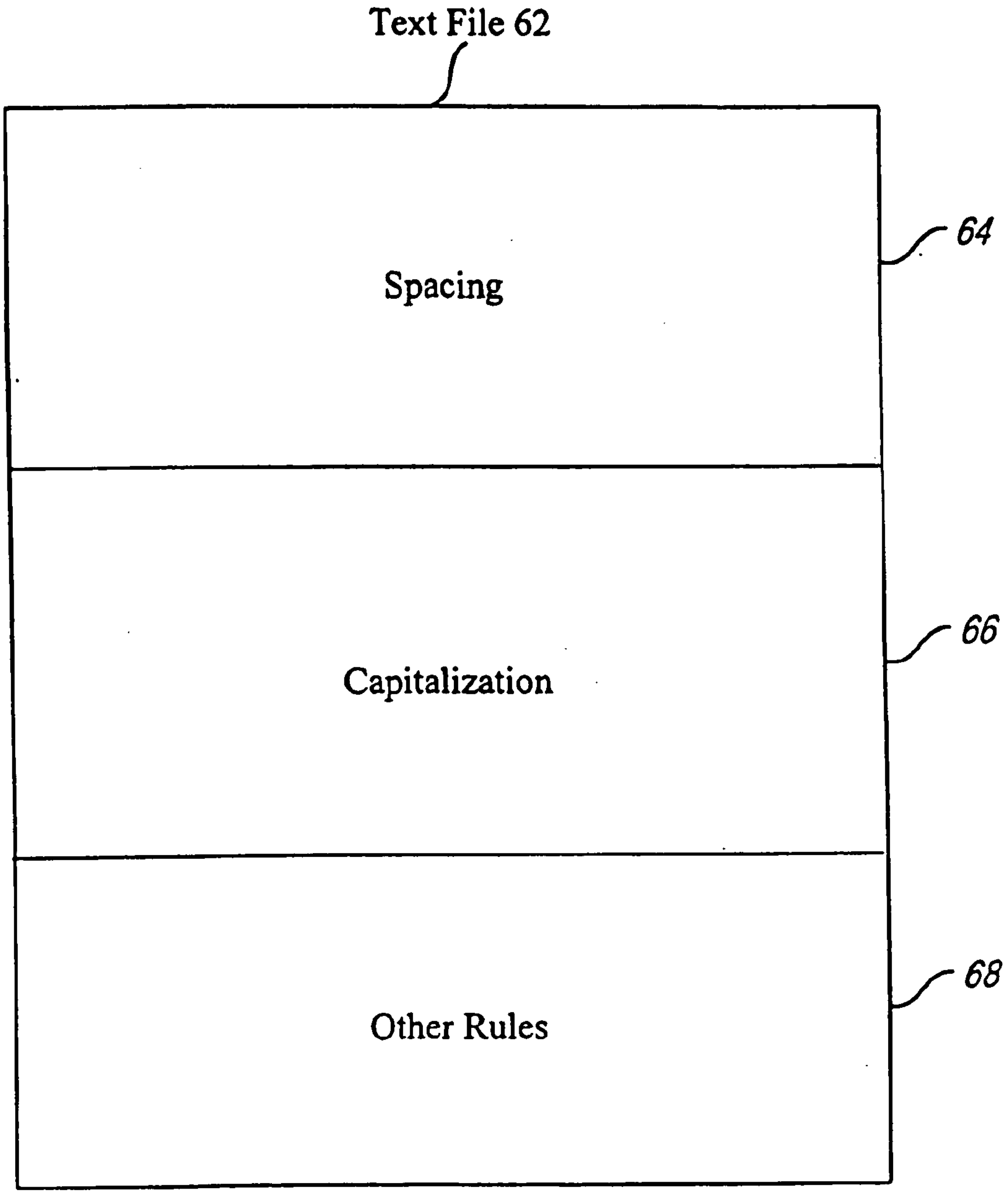


Fig. 4

Categories of Other Rules

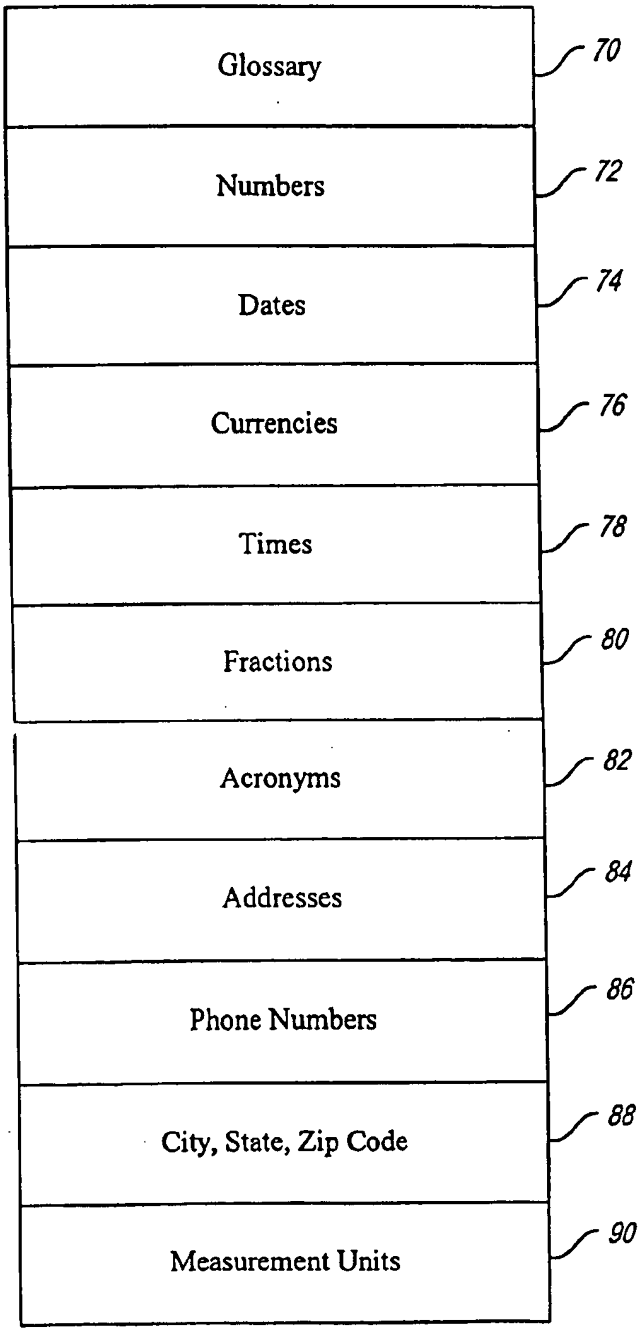


Fig. 5

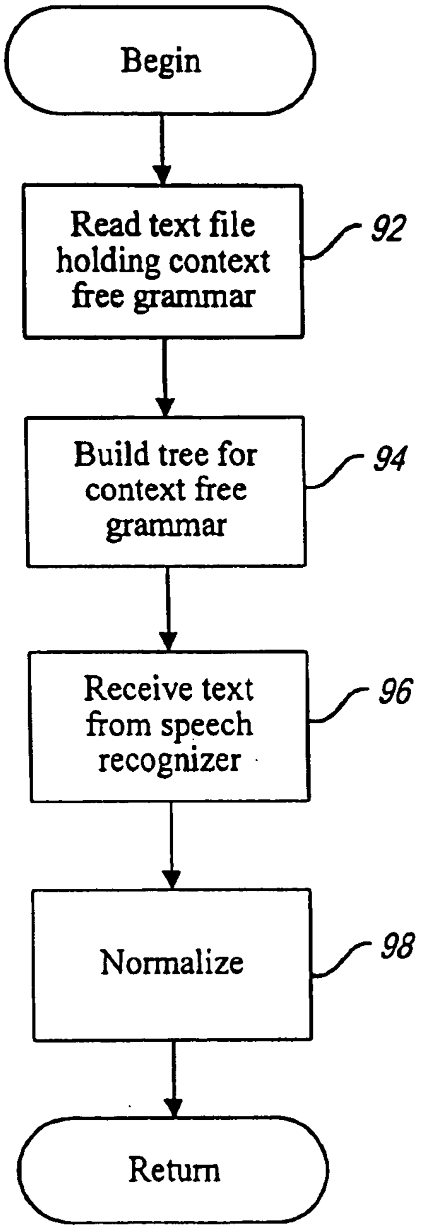

Begin
Read text file holding context free grammar
92
Build tree for context free grammar
94
Receive text from speech recognizer
96
Normalize
98
Return

Fig. 6

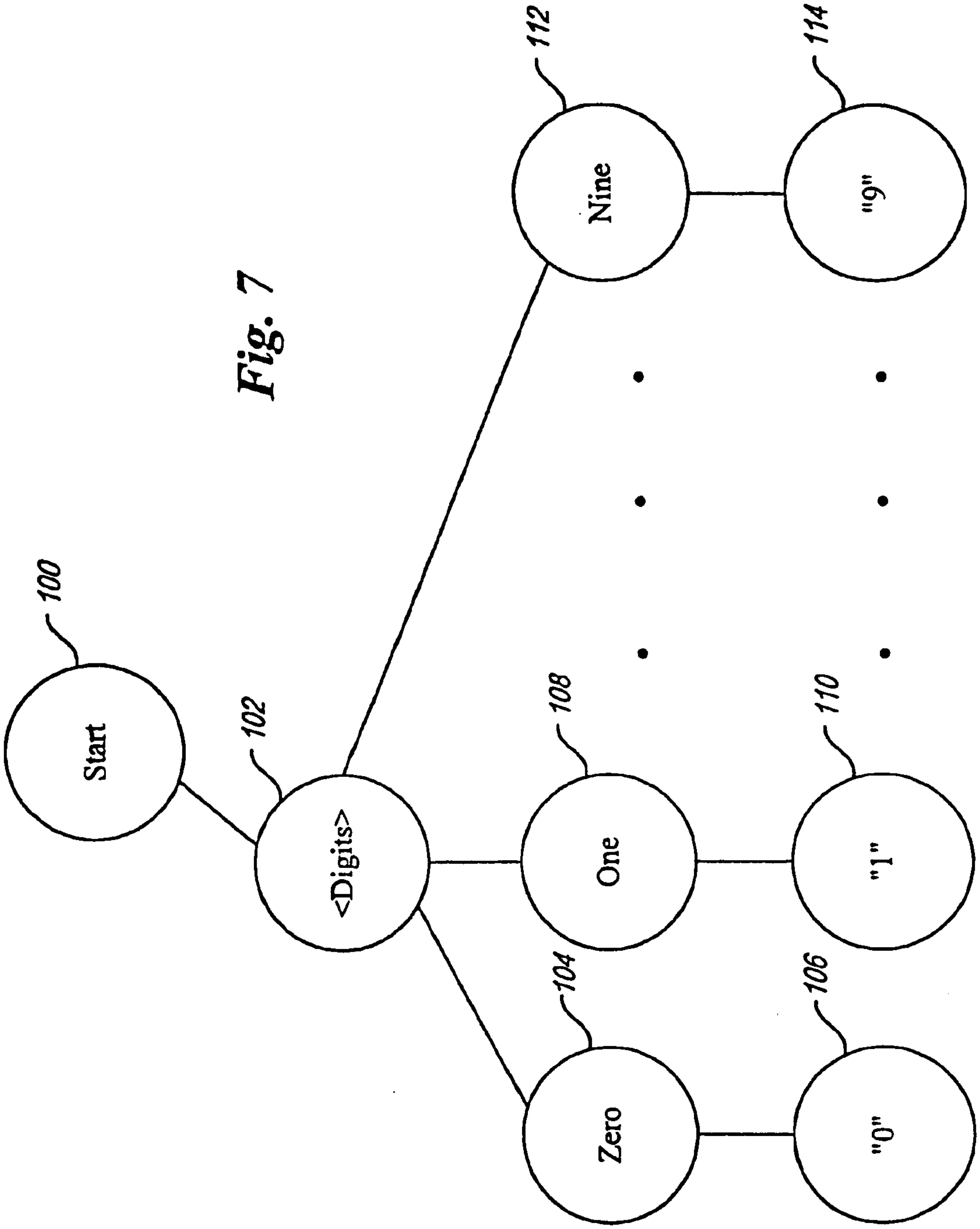


Fig. 7

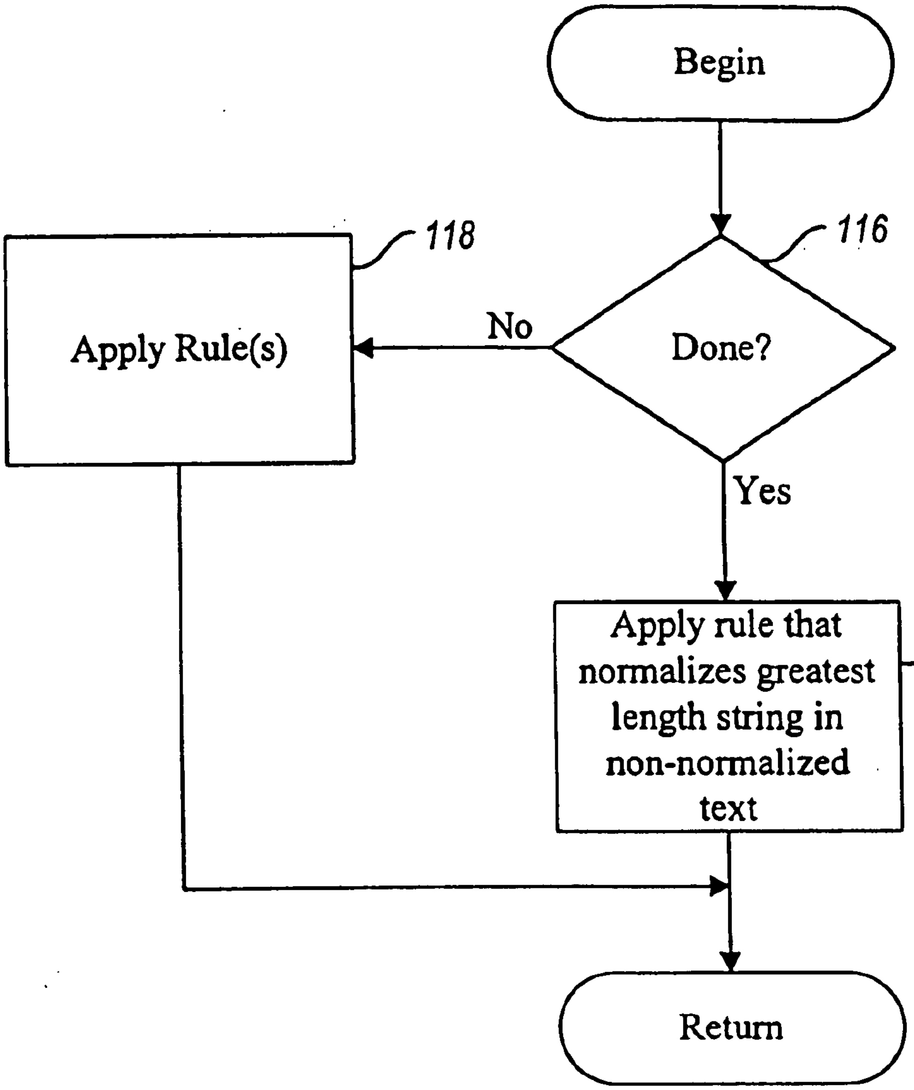

Begin
116
Done?
No
118
Apply Rule(s)
Yes
120
Apply rule that normalizes greatest length string in non-normalized text
Return

Fig. 8

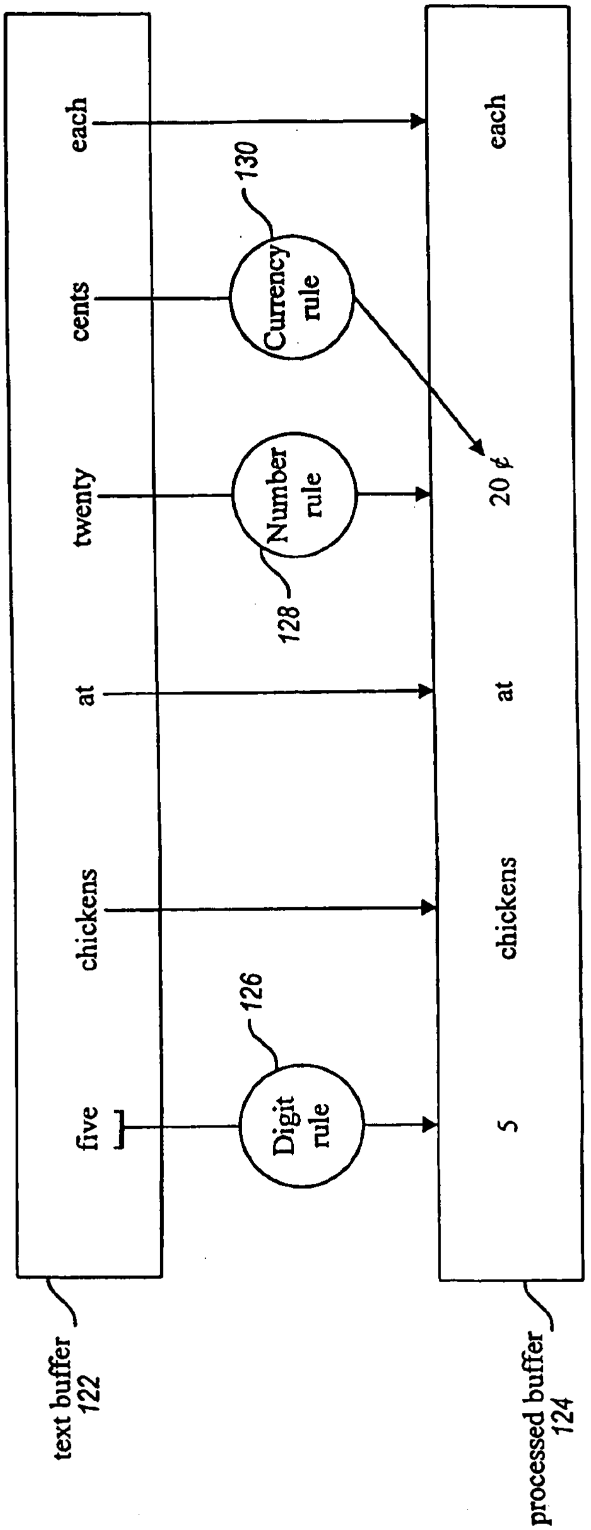

five
chickens
at
twenty
cents
each
Digit rule
126
Number rule
128
Currency rule
130
5
chickens
at
20 ¢
each
text buffer 122
processed buffer 124

Fig. 9

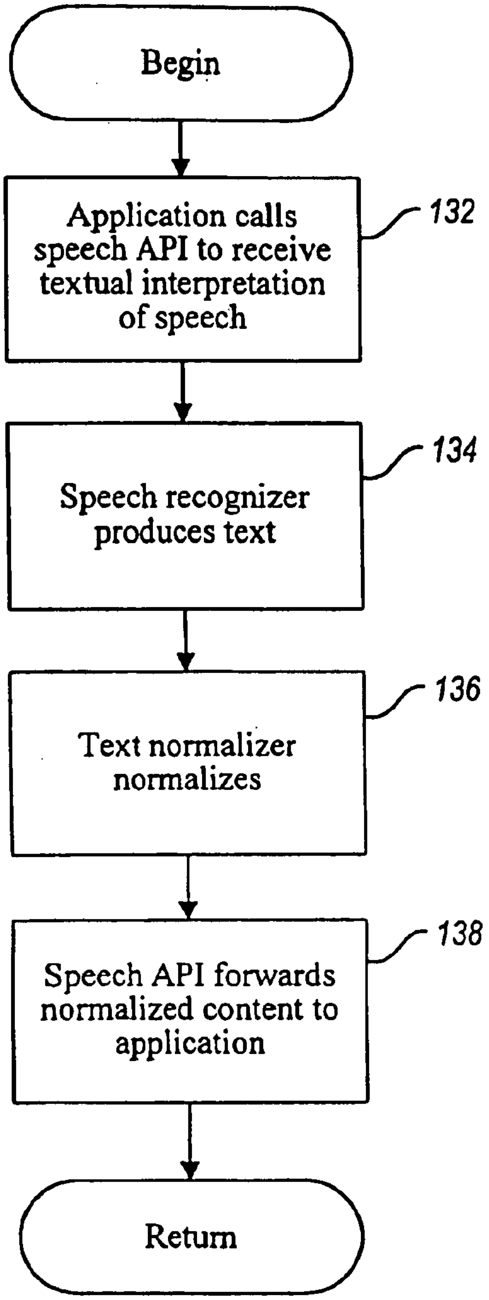

Begin
Application calls speech API to receive textual interpretation of speech
132
Speech recognizer produces text
134
Text normalizer normalizes
136
Speech API forwards normalized content to application
138
Return

Fig. 10

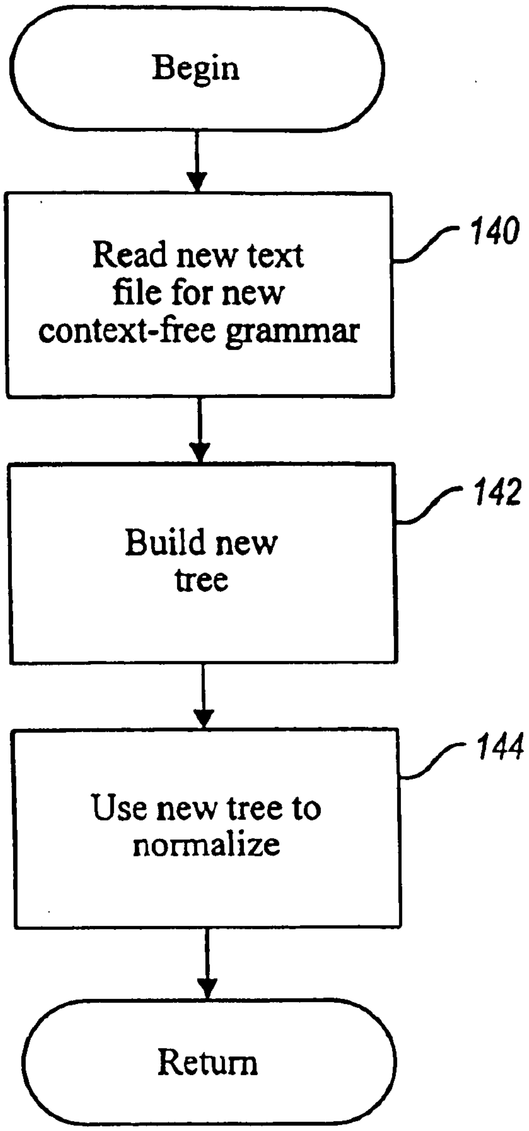

Begin
Read new text file for new context-free grammar
140
Build new tree
142
Use new tree to normalize
144
Return

Fig. 11

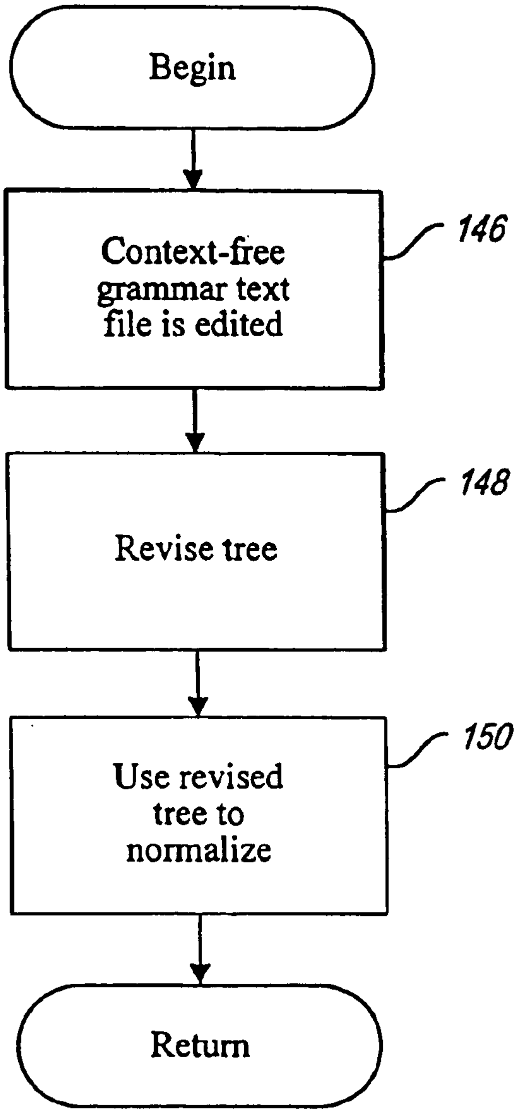

Begin
Context-free grammar text file is edited
146
Revise tree
148
Use revised tree to normalize
150
Return

Fig. 12

TEXT NORMALIZATION USING A CONTEXT-FREE GRAMMAR

TECHNICAL FIELD

The present invention relates generally to data processing systems, and more particularly, to text normalization using a context-free grammar.

BACKGROUND OF THE INVENTION

Speech recognizers have gained popularity in recent years. A speech recognizer typically includes software that is run on a computer system to recognize spoken words or phrases. The speech recognizer generally outputs text corresponding to its interpretation of the spoken input. For example, if a speaker speaks the word "dog," the speech recognizer recognizes the spoken word and outputs the text "dog."

Unfortunately, speech recognizers often produced textual output that is awkward or not familiar to recipients. For example, if a speaker speaks the phrase "one hundred forty seven," the speech recognizer outputs "one hundred forty seven" rather than the sequence of digits "147." Similar awkward textual outputs are produced by speech recognizers for inputs that specify dates, times, monetary amounts, telephone numbers, addresses, and acronyms. As a result, the recipient of the textual output is forced to manually edit the text to put it in a more acceptable form. As speech recognizers are being incorporated in document creation software, the inability of the speech recognizers to produce acceptable textual output substantially diminishes the usefulness of such software.

SUMMARY OF THE INVENTION

The present invention overcomes the limitation of prior art speech recognizers by providing a facility for normalizing text. The normalization of text produces output text that is more acceptable to recipients. The normalization may also include the substitution of textual content with non-textual content, such as audio content, video content, or even a hypertext document.

In accordance with a first aspect of the present invention, a method is practiced in a computer system that has a speech recognition engine for recognizing content in an input speech. Text corresponding to speech input is received from the speech recognition engine by the computer system. A context-free grammar is applied to identify substitute content for the received text. The receive text is substituted with the substitute content.

In accordance with another aspect of the present invention, a file is provided in a computer system to set forth rules of a context-free grammar for normalizing text. Text is received from a speech recognizer that recognizes portions of speech in speech input. The text corresponds to speech input. At least a portion of the text is normalized to replace the portion with a normalized alphanumeric string ("alphanumeric" as used in this context is intended to include ASCII and Unicode). The normalizing comprises applying a rule from the context-free grammar to replace the portion of the text being normalized with the normalized alphanumeric string.

In accordance with an additional aspect of the present invention, an application program interface (API) that includes a text normalizer is provided within a computer system. The computer runs an application program and includes a speech recognizer for recognizing portions of speech in speech input and for outputting text that corresponds to the recognized portions of speech. Text is received from the speech recognizer at the text normalizer. The text is normalized by the text normalizer by applying a rule from the context-free grammar to alter contents of the text and produce normalized text. The normalized text is passed to the application program.

In accordance with a further aspect of the present invention, a computer system includes a speech recognizer for recognizing portions of speech in speech input and for producing textual output corresponding to the recognized portions of speech. The computer system also includes a context-free grammar that contains rules for normalizing text and a text normalizer that applies at least one rule from the context-free grammar to normalize textual output from the speech recognizer.

Outputting
prose read.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention will be described below relative to the following figures.

FIG. 1 is a block diagram illustrating a computer system that is suitable for practicing the preferred embodiment of the present invention.

FIG. 2 is a block diagram illustrating a distributed system that is suitable for practicing the preferred embodiment of the present invention.

FIGS. 3A–3E illustrate the data flow between the speech recognizer, the text normalizer, and the application programs for different types of normalization.

FIG. 4 illustrates the logical format of the text file that holds the context-free grammar.

FIG. 5 depicts the categories of other rules that are set forth within the text file of FIG. 4.

FIG. 6 is a flow chart illustrating the steps that are performed to use the text file for normalizing text.

FIG. 7 depicts an example portion of the tree for the context-free grammar.

FIG. 8 is a flow chart illustrating the steps that are performed to determine when to apply a rule from the context-free grammar.

FIG. 9 depicts an example of normalization of a portion of text.

FIG. 10 is a flow chart illustrating the steps that are performed for an application program to receive normalized text.

FIG. 11 is a flow chart illustrating the steps that are performed to replace one context-free grammar with another.

FIG. 12 is a flow chart illustrating the steps that are performed to edit a context-free grammar.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment of the present invention provides a mechanism for normalizing text that is received from a speech recognizer. A context-free grammar is applied to perform the text normalization. The context-free grammar includes a number of rules that specify how the text is to be normalized. These rules are applied to textual output received from the speech recognizer to produce normalized text. In the preferred embodiment of the present invention, the text normalization is performed within an application program interface (API) that may be called by application programs to receive text corresponding to speech input.

The preferred embodiment of the present invention may provide multiple types of text normalization. For example, text may be normalized to produce normalized text. Similarly, text may be normalized to produce different types of media content. Text may be normalized to produce audio content and video content. Text may even be normalized to produce hypertext documents that are substituted for the text.

The context-free grammar utilized in the preferred embodiment of the present invention is extensible. The context-free grammar, as will be described in more detail below, is specified within a text file. This text file may be replaced with a substitute text file that specifies a different context-free grammar. Moreover, the text file may be edited so as to alter the contents of the context-free grammar. As the context-free grammar is specified within a text file, the context-free grammar is human-readable.

FIG. 1 depicts a computer system **10** that is suitable for practicing the preferred embodiment of the present invention. The computer system **10** includes a central processing unit (CPU) **12** that oversees operations of the computer system. The CPU **12** may be realized by any of a number of different types of microprocessors. The computer system may also include a number of peripheral devices, including a keyboard **14**, a mouse **16**, a microphone **18**, a video display **20**, and a loud speaker **22**. The microphone **18** may be used to receive speech input from a speaker, and a loud speaker **22** may be used to output audio content, such as speech. The computer system **10** may also include a network adapter **24** for interfacing the computer system with a network, such as a local area network (LAN) or wide area network (WAN). Those skilled in the art will appreciate that a number of different types of network adapters may be utilized in practicing the present invention. The computer system **10** may also include a modem for enabling the computer system to communicate with a remote computing resources over an analog telephone line.

The computer system **10** additionally includes a primary memory **28** and a secondary memory **30**. The primary memory may be realized as random access memory (RAM) or other types of internal memory storage known to those skilled in the art. The secondary storage **30** may take the form of a hard disk drive, CD-ROM drive, or other type of secondary storage device. In general, the secondary memory **30** may be realized as a secondary storage device that stores computer-readable removable storage media, such as CD-ROMs.

The primary memory **28** may hold software or other code that constitute a speech recognizer **32**. The speech recognizer may take the form of a speech recognition engine and may include ancillary facilities such as a dictionary and alike. A suitable speech recognition engine is described in co-pending application, entitled "Method And System For Speech Recognition Using Continuous Density Hidden Markov Models," application Ser. No. 08/655,273, which was filed on May 1, 1996 and which is explicitly incorporated by reference herein. Those skilled in the art will appreciate that portions of the speech recognizer **32** may also be stored on the secondary memory **30**. The primary memory **28** holds a speech application program interface (API) **34** that works with the speech recognizer **32** to produce textual output corresponding to recognized speech within speech input. Application programs **36** may call the speech API **34** to receive the textual output that corresponds to the recognized portions of the speech input. These application programs **36** may include dictation applications, word processing programs, spreadsheet programs and the like. The speech API **34** may include a text normalizer **38** for performing text normalization. The text normalizer **38** is the resource that is responsible for normalizing the text that is received by the speech API **34** from the speech recognizer **32**. The types of normalization that are performed by the text normalizer **38** will be described in more detail below.

Those skilled in the art will appreciate that the text normalizer **38** need not be part of the speech API **34** but rather may exist as a separate entity or may be incorporated into the speech recognizer **32**. The speech recognizer uses a context-free grammar **40** that is shown in FIG. **1** as being stored in secondary storage **30**. Those skilled in the art will appreciate that the context-free grammar **40** may also be stored in primary memory **28**.

It should be appreciated that the computer system configuration depicted in FIG. **1** is intended to be merely illustrative and not limiting of the present invention. The present invention may be practiced with other computer system configurations. These other configurations may include fewer components than those depicted in FIG. **1** or may include additional components that differ from those depicted in FIG. **1**. Moreover, the present invention need not be practiced on a single processor computer but rather may be practiced in multiprocessor environments, including multiprocessors and distributed systems.

FIG. **2** depicts an instance where the computer system **10** is a client computer that has access to a network **44**. This network **44** may be a LAN or a WAN. The network **44** may be the Internet, an Intranet or an Extranet. The client computer **10** includes networking support **42**. This networking support **42** may include client code for a network operating system, a conventional operating system or even a web browser. The networking support **42** enables the client computer **10** to communicate with the server **46** within the network **44**. The server **46** may hold media content **48**, such as audio data, video data, textual data, or a hypertext document that is to be used by the client computer **10** in normalizing text.

As was mentioned above, the text normalizer **38** normalizes the text received from the speech recognizer **32** to produce normalized content. FIG. **3A** depicts the flow of data between the speech recognizer **32**, the text normalizer **38**, and an application program **36**. In general, the speech recognizer **32** outputs text **50** that corresponds to recognized portions of speech within speech input received via the microphone **18** or stored in secondary storage **30**. The text **50** may output a word at a time to the text normalizer **38**. Nevertheless, those skilled in the art will appreciate that the granularity of textual output produced by the speech recognizer **32** may vary and may include letters or even phrases. The text normalizer **38** produces normalized content **52** that it passes on to an application program **36**.

FIG. **3B** shows an instance where the text normalizer **38** produces normalized text **54** that it passes to the application program **36**. The normalized text **54** includes substitute text that replaces the text **50** that was output by the recognizer **32**. However, as shown in FIG. **3C**, the text normalizer **38** may, alternatively, normalize the text to produce image data **56**, such as a bitmap, metafile, or other representation of an image to the application program **36**. The text **50** may specify an identifier of the representation of the image. In this instance, the text normalizer **38** replaces the identifier with the actual representation of the image that is identified by the identifier.

FIG. **3D** shows an instance wherein the text normalizer **38** receives text **50** from the speech recognizer **32** and produces audio content **58** as the normalized content. In this case, the text **50** may identify an audio clip or a file that holds audio data. This identifier is replaced with the associated audio clip for a file when normalized. Alternatively, the text may be a word or phrase for which the text normalizer **38** has an audio representation and wishes to substitute the audio representation for the word or phrase.

FIG. 3E depicts an instance wherein the text normalizer **38** receives text **50** from the speech recognizer **32** and outputs a hypertext document **60** to the application program **36**. The text **50** may include an identifier, such as a uniform resource location (URL) that is associated with the hypertext document **60**. When the text normalizer **38** receives the text **50** for normalization, it replaces the text with the associated hypertext document **60**.

It should be appreciated that the text normalizer may combine different types of media content in the resulting normalized content **52** that is passed the application programs. It should also be appreciated that the text normalizer **38** may draw upon media content or resources within a network **44** to realize the normalization. For purposes of simplicity and clarity, the discussion below will focus on instances like that depicted in FIG. 3B wherein text **50** is normalized by the text normalizer **38** to produce normalized text **54**.

As was mentioned above, the context-free grammar **40** is stored as a text file. The text file holds specification of the rules of the context-free grammar. FIG. **4** depicts a logical organization of the text file **62**. The text file **62** is divided into three major sections **64**, **66**, and **68**. Each of the sections is delineated by a header or tag within the text file **62** (e.g., "[spacing]," "[capitalization]," "[Rules]"). The first section is the spacing section **64** that specifies rules of the context-free grammar relative to spacing. These rules are implemented as a table. An example of a specification of rules within the table is as follows:

left	right	substitution	switch
"."	" "	"00"	{1}
"."	" "	"0"	{!1}

The table includes a "left" column that specifies a character that appears to the left, a "right" column that specifies a character that appears to the right, a "substitution" column that holds a proposed substitution for the right character, and a "switch" column that specifies whether the rule is in effect or not. The first rule in the above example specifies that if a period (i.e., the left character) is followed by a space (i.e., the right character), two spaces are to be substituted for the single space. The switch column holds a value of "1" and thus indicates that this rule is in effect. The second rule (specified underneath the first rule in the above example) indicates that a period is to be followed only a single space. The switch column, however, holds a value of "!1," which indicates that the rule is not in effect.

It should be noted that a user interface, such as a property sheet, may be provided to enable a user to choose which of the spacing rules are in effect or not. The user choices are used to set the switch fields within the table.

The capitalization section **66** is also organized as a table like that provided for the spacing section **64**. This section **66** holds capitalization rules such as the first letter of a word following a period that ends a sentence is capitalized. These rules may be also implemented as switchable so that a user may choose capitalization options.

The third section is the other rule section **68**. The other rule section holds specification of a number of different rules that do not concern capitalization or spacing. This section is delineated by a "Rules" heading or tag. An example of such a rule is as follows:

```
<Digits> = [1+] <0..9>
 <0..9> = zero "0"
 <0..9> = one "1"
      .    .
      .    .
      .    .
 <0..9> = nine "9"
```

This rule indicates written digits may include one or more words containing digits and the rule specifies the substitution of digits for written digit strings (i.e., "1" for "one").

FIG. **5** depicts the categories of other rules that may be implemented in accordance with the preferred embodiment of the present invention. The glossary category of rule **70** specifies the replacement of text with the substitute text. A user may type in such substitutions as part of the glossary to enable shorthand ways of adding text to a document. The numbers category **72** contains rules that specify the substitution of the written form of words (i.e., a string of words) with a digital representation composed solely of digits. For example, "one hundred forty seven" is replaced by "147" by application of rules in this category **72** of rules.

A dates category **74** contains rules that concern how spoken versions of dates are to be normalized. For example, the output text "april first nineteen ninety seven" is normalized to "Apr. 1, 1997."

The currencies category **76** holds rules that normalize the specification of monetary amounts. For example, the phrase "ten cents" may be normalized to "10¢" by rules in this category **76**.

The times category **78** holds rules that are used to normalize specification of time. For instance, the text "four o'clock in the afternoon" may be normalized to "4 p.m." by rules within this category **78**.

The fractions category **80** normalizes fractions into a mathematical form. Hence, the text "one-fourth" may be normalized to "¼" by rules in this category **80**.

The acronyms category **82** normalizes text that specifies acronyms. For example, the text "CIA" may be normalized to "C. I. A." by rules in this category **82**.

The addresses category **84** contains rules for normalizing the specification of addresses. For instance, the string "one hundred fifty sixth" may be normalized to "156th" by rules within this category **84**.

The phone numbers category **86** normalizes the specification of phone numbers. When a user speaks a phone number, the speech recognizer may interpret the phone number as merely a sequence of digits. For example, the string "nine three six six three zero zero zero" may be normalized to "936-3000" by rules within this category **86**.

The city, state, zip code category **88** holds rules for specifying how a sequence of city, state, and zip code should appear. For example, the text "Seattle Washington nine eight zero five two" may be normalized to "Seattle, Wash. 98052" by rules within this category **88**.

The measurement units category **90** applies rules regarding the specification of measurements. For instance, the text "nineteen feet" will be normalized to "19 ft." by rules within this category **90**.

Those skilled in the art will appreciate that the text file **62** may have a different format other that depicted within FIG. **4**. Moreover, the text file **62** may include rules for substituting text with audio content or video content. Rules may also be included for substituting text with hypertext documents. Those skilled in the art will appreciate that the context-free grammar need not be specified as a text file in practicing the present invention.

Those skilled in the art will further appreciate that additional categories of rules other than those depicted in FIG. 5 may be utilized. Still further, fewer categories of rules or different categories of rules may apply other than those depicted in FIG. 5.

In order to utilize the context-free grammar **40**, the text file **62** must be read and processed. FIG. **6** is a flowchart that depicts the steps that are performed to utilize the context-free grammar in normalizing text. First, the text file **62** that holds the context-free grammar is read (step **92** in FIG. **6**). The content held therein are used to build a tree representation for the context-free grammar (step **94** in FIG. **6**). This tree representation is used in parsing the input text received from the speech recognizer **32**. Each path of the tree specifies a portion of a rule for normalizing text. Thus, the text received from the speech recognizer **32** is processed by the text normalizer **38** to compare the text with the rules contained within the tree and perform the appropriate normalization. Accordingly, text is received from the speech recognizer (step **96** in FIG. **6**) and normalized (step **98** in FIG. **6**). The tree acts largely as a parsing mechanism for deciding what portions of text received from the speech recognizer **32** should be normalized and how these portions should be normalized.

Parse

FIG. **7** shows an example of a portion of the tree that is built by reading rules from the text file. The tree may be stored in binary form for optimization. This subtree specifies portions of the "Digits" rule that was set forth above as an example of rules provided within the text file **62**. The tree includes a start rule node **100** followed by a digits rule node **102**. Nodes **104** and **106** specify that if the received text is "zero" the text is to be normalized and replaced with "0." Similarly, nodes **108**, **110**, **112**, and **114** indicate the substitutions of "1" for "one" and "9" for "nine," respectively.

An example is helpful in illustrating how the subtree depicted in FIG. **7** may be used. Suppose that the text normalizer **38** receives the string "zero" the text normalizer starts at the start rule **100** and then determines that the string "zero" specifies a digit. It then follows the path to node **104** and determines that there is a match. The text normalizer then uses the substitute or normalized string "0" specified in node **106** to normalize the received string.

The rules are not necessarily applied on a word-by-word basis. Instead, the system seeks to apply the rule that will normalize the greatest length string within the text received from the speech recognizer **32**. FIG. **8** is a flowchart illustrating the steps that are performed in applying the rules. In general, a rule will be applied when at least a complete rule has been identified and no further portion of a rule can be applied. Thus, in step **116** of FIG. **8**, the text normalizer determines whether it is done normalizing a given portion of a text. If the text normalizer is done (see step **116** in FIG. **8**), the text normalizer applies the rule that normalizes the greatest length of string in the non-normalized text (step **120** in FIG. **8**). It should be noted that there may be instances where multiple rules apply and there has to be a criteria for determining which rule to actually utilize. The preferred embodiment of the present invention utilizes the rule that normalizes the greatest portion of the non-normalized string. If, however, it is determined that there is further application of the rules to be done (see step **116** in FIG. **8**), then the additional portions of the rules are applied (step **118** in FIG. **8**).

An example is helpful in illustrating when rules are applied and how normalization is performed. FIG. **9** depicts an example of text string "five chickens at twenty cents each." These words are stored within a text buffer **122** that is used by the text normalizer **38**. The first word, "five," is processed by the text normalizer to determine whether there are any matching rules or not. There will be a match within the digit rule **126** for this word. Before applying the rule, the text normalizer **38** looks at the next word "chickens" as there is no rule that applies to the phrase "five chickens," the text normalizer **38** knows that it is done (see step **116** in FIG. **8**) and applies the digit rule to replace "five" with "5." The value "5" is stored in a processed buffer **124** that holds the normalized text output.

The system has no rule for "chickens" and thus does not pass the word on to the processed buffer **124**. Similarly, the text normalizer **38** has no rule for the word "at" and thus would pass the word "at" on to the process buffer **124**. When the text normalizer **38**, however, encounters "twenty," it has a rule that applies (a number rule **128**). Before actually using the rule, the text normalizer **38** looks at the next word "cents" and determines that there is no rule that normalizes the phrase "twenty cents." As a result, the number rule **128** is applied to replace "twenty" with "20." Subsequently, a currency rule **130** is applied to replace "cents" with "¢." Lastly, the word "each" is not normalized and is passed in literal form to the process buffer **124**.

As was mentioned above, the text normalizer **38** is used within the speech API **34**. FIG. **10** is a flow chart that depicts the steps of how the text normalizer is used in this context. Initially, an application program **36** calls the speech API **34** to receive textual interpretation of input speech (step **132** in FIG. **10**). A speech recognizer processes the speech input to produce a textual output (step **134** in FIG. **10**). The text normalizer **38** then normalizes the text as has been described above (step **138** in FIG. **10**). The speech API **34** forwards the normalized content to the requesting application program **36** (step **138** in FIG. **10**).

The preferred embodiment of the present invention has the benefit of being flexible and extensible. The context-free grammar is extensible in that content may be changed, added, or a complete new context-free grammar may be specified. FIG. **11** is a flow chart illustrating the steps that are performed to replace the context-free grammar with a new context-free grammar. The existing context-free grammar may be replaced by providing a new text file. A new text file holds specification for the new context-free grammar. The computer system **10** then reads the new text file for the context-free grammar (step **140** in FIG. **11**). The information within the text file is utilized to build a new tree for the new context-free grammar (step **142** in FIG. **11**). The new tree is then used to normalize text (step **144** in FIG. **11**).

The entire text file need not be replaced each time the user wishes to change the context-free grammar. Instead, the text file may be merely edited. FIG. **12** is a flow chart illustrating the steps that are performed to alter the context-free grammar in this fashion. Initially, the context-free grammar checks file as edited (step **146** in FIG. **12**). The tree is revised accordingly by reading the contents from the edited text file altering the tree in a matching fashion (step **148** in FIG. **12**). The revised tree may then be utilized to normalized text (step **150** in FIG. **12**).

While the present invention has been described with reference to a preferred embodiment thereof, those skilled in the art will appreciate that various changes in the form and detail may be made without departing from the intended scope of the present invention as defined in the appended claims. For example, the text normalization may generally be applied to substitute textual content with any of a number of different types of media. Moreover, the text normalizer need not be part of a speech API or part of system provided resources.

We claim:

1. In a computer system having a speech recognition engine for recognizing content in input speech, a method comprising the computer-implemented steps of:

receiving text corresponding to speech input from the speech recognition engine;

applying a context-free grammar to identify substitute content for the received text; and

substituting the text with the substitute content.

2. The method of claim 1 wherein the substitute content comprises an alphanumeric string.

3. The method of claim 1 wherein the substitute content comprises graphical content.

4. The method of claim 1 wherein the received text is an identifier of media content in a distributed system and the substitute content is the media content.

5. The method of claim 4 wherein the received text is a uniform resource locator (URL).

6. The method of claim 5 wherein the substitute content is a hypertext document.

7. The method of claim 1 wherein the substitute content is a hypertext document.

8. The method of claim 1 wherein the substitute context comprises audio content.

9. The method of claim 1 wherein the context-free grammar contains at least one rule for substituting the substitute content for the received text.

10. The method of claim 1 wherein the computer system runs an application program and wherein the substitute content is forwarded to the application program.

11. The method of claim 1 wherein the received text is a string of words and the substitute content contains a series of digits corresponding to at least some of the string of words.

12. The method of claim 1 wherein the received text is a string of words specifying an address and the substitute content includes a series of digits specifying at least a portion of the address.

13. The method of claim 1 wherein the received text is a string of words identifying an amount of currency and the substitute content includes digits and a currency symbol that specifies the amount of currency.

14. The method of claim 1 wherein the received text is a string of words that specifies a fraction and the substitute content includes digits and a mathematical operation that in conjunction specify the fraction.

15. In a computer system having a speech recognizer for recognizing portions of speech in speech input, a method comprising the computer-implemented steps of:

providing a file that sets forth rules of a context-free grammar for normalizing text;

receiving text from the speech recognizer, said text corresponding to speech input; and

normalizing at least a portion of said text to replace the portion of said text with a normalized alphanumeric string, said normalizing comprising applying a rule from the context-free grammar to replace the portion of said text being normalized with the normalized alphanumeric string.

16. The method of claim 15, further comprising the steps of replacing the file with a substitute file that sets forth rules of a different context-free grammar and using the different context-free grammar to normalize new text.

17. The method of claim 15, further comprising the step of using the file to build a tree for the context-free grammar that is used in the normalizing.

18. The method of claim 15 wherein the file is a text file.

19. The method of claim 15 wherein the file includes rules regarding capitalization.

20. The method of claim 15 wherein the file includes rules regarding spacing.

21. The method of claim 15 wherein the file contains specification of a switch that identifies whether or not a rule is to be used as part of the context-free grammar.

22. The method of claim 15, further comprising the step of altering contents of the file so as to change the context-free grammar.

23. The method of claim 15, further comprising the steps of receiving additional text and normalizing the additional text by applying another rule from the context-free grammar to replace the additional text with non-textual content.

24. The method of claim 23 wherein the non-textual content includes image data.

25. The method of claim 23 wherein the non-textual content includes audio data.

26. In a computer system having an application program and a speech recognizer for recognizing portions of speech in speech input and outputting text corresponding to the recognized portions of speech, a method comprising the computer implemented steps of:

providing an application program interface (API) that includes a text normalizer;

receiving text from the speech recognizer at the text normalizer;

normalizing the text by applying a rule from a context-free grammar to alter contents of the text and produce normalized text; and

passing the normalized text to the application program.

27. The method of claim 26 wherein the API is a speech API that provides textual output corresponding to recognized speech input to the application program.

28. The method of claim 26 wherein the application program requests text from the API to prompt the passing of the normalized text to the application program.

29. A computer system, comprising:

a speech recognizer for recognizing portions of speech in speech input and producing textual output corresponding to the recognized portions of speech;

a context-free grammar that contains rules for normalizing text; and

a text normalizer that applies at least one rule from the context-free grammar to the textual output from the speech recognizer.

30. The computer system of claim 29 wherein the text normalizer is part of an application program interface (API).

31. In a system having a speech recognition engine for recognizing content in input speech, a computer-readable medium holding computer-executable instructions for performing a method comprising the computer-implemented steps of:

receiving text corresponding to speech input from the speech recognition engine;

applying a context-free grammar to identify substitute content for the received text; and

substituting the text with the substitute content.

32. The computer-readable medium of claim 31 wherein the substitute content comprises an alphanumeric string.

33. The computer-readable medium of claim **31** wherein the substitute content comprises graphical content.

34. The computer-readable medium of claim **31** wherein the received text is an identifier of media content in a distributed system and the substitute content is the media content.

35. The computer-readable medium of claim **34** wherein the received text is a uniform resource locator (URL).

36. The computer-readable medium of claim **35** wherein the substitute content is a hypertext document.

37. The computer-readable medium of claim **31** wherein the substitute content is a hypertext document.

38. The computer-readable medium of claim **31** wherein the substitute content comprises audio content.

39. The computer-readable medium of claim **31** wherein the received text is a string of words and the substitute content contains a series of digits corresponding to at least some of the string of words.

40. The computer-readable medium of claim **31** wherein the received text is a string of words specifying an address and the substitute content includes a series of digits specifying at least a portion of the address.

41. The computer-readable medium of claim **31** wherein the received text is a string of words identifying an amount of currency and the substitute content includes digits and a currency symbol that specifies the amount of currency.

42. The computer-readable medium of claim **31** wherein the received text is a string that specifies a fraction and the substitute content includes digits and a mathematical operation that in conjunction specify the fraction.

43. In a computer system having a speech recognizer for recognizing portions of speech in speech input, a computer-readable medium holding computer-executable instructions for performing a method comprising the computer-implemented steps of:

providing a file that sets forth rules of a context-free grammar for normalizing text;

receiving text from the speech recognizer, said text corresponding to speech input; and

normalizing at least a portion of said text to replace the portion of said text with a normalized alphanumeric string, said normalizing comprising applying a rule from the context-free grammar to replace the portion of said text being normalized with the normalized alphanumeric string.

44. The computer-readable medium of claim **43** wherein the method further comprises the steps of replacing the file with a substitute file that sets forth rules of a different context-free grammar and using the different context-free grammar to normalize new text.

45. The computer-readable medium of claim **43** wherein the file is a text file.

46. The computer-readable medium of claim **43** wherein the file contains specification of a switch that identifies whether or not a rule is to be used as part of the context-free grammar.

47. The computer-readable medium of claim **43** wherein the method further comprises the step of altering contents of the file to change the context-free grammar.

48. In a computer system having an application program and a speech recognizer for recognizer portions of speech in speech input and outputting text corresponding to the recognized portions of speech, a computer-readable medium holding computer-executable instructions for performing a method comprising the computer-implemented steps of:

providing an application program interface (API) that includes a text normalizer;

receiving text from the speech recognizer at the text normalizers;

normalizing the text by applying the rule from a context-free grammar to alter contents of the text and produce normalized text; and

passing the normalized text to the application program.

49. The computer-readable medium of claim **48** wherein the API is a speech API that provides textual output correspond to recognized speech input to the application program.

50. The computer-readable medium of claim **48** wherein the application program requests text from the API to prompt the passing of the normalized text to the application program.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	:	5,970,449
DATED	:	October 19, 1999
INVENTOR(S)	:	Alleva et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Page 1 of 1

Column 1, line 48, replace "receive" with --received--.

Column 8, line 18, replace "process" with --processed--.

Column 8, line 27, replace "process" with --processed--.

Column 11, line 28, after "string" insert --of words--.

Column 12, line 28, replace "normalizers" with --normalizer--.

Signed and Sealed this

Third Day of April, 2001

Attest:

Nicholas P. Godici

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office